

German foreign trade with R&D-intensive products has grown considerably faster than trade with other processed industrial goods, and this applies equally for imports and exports. In cutting-edge technology, medical equipment and measuring technology products are the most important exports, whereas computer equipment and medical and measuring technology are in the lead among the imports. Foreign trade with high-level technology is dominated by the automotive industry, which accounts for more than half of the exports and imports. Mechanical engineering products are a considerable way behind in second place, and then again some distance behind follow chemical and electrical engineering products.

Shrinking advantage in foreign trade

» D 2 Looking at the foreign trade balance, Germany is showing a deficit regarding cutting-edge technology products, but a surplus with high-level technology products. These structures are usually analysed in terms of the Revealed Comparative Advantage (RCA) index.⁷⁵ A positive value of this index is interpreted as a showing of a foreign trade position for a specific group of a country's products which is stronger than its overall economic position. Since the beginning of the 1990s, there has been a gradual decline in the values of this RCA index for Germany, because imports have increased more rapidly than exports. For cutting-edge technology products, the values are clearly negative (Figure 09), whereas for high-level technology the index is positive. Overall, the foreign trade position in high technology is slightly above average, although showing a downward trend.

The influence of various categories of products on Germany's competitive position is demonstrated by their relative contribution to the balance of trade. A comparison over the past decade shows that the figures for R&D intensive goods have declined markedly from 3.8 in 1996 to 1.5 in 2006 (Figure 10). For cutting-edge technology goods the figures are even more negative, and for high-level technology the positive value has fallen. However, the overall profile of specialisation has hardly changed. Significant positive contributions are provided by automotive manufacturing and mechanical engineering. The values are negative for telecommunications, office machinery, and computer equipment. There has been a reversal from positive to negative in the cases of chemicals and pharmaceutical products. In all, the strengths and

weaknesses in foreign trade are a reflection of the production situation.

It is more difficult to judge Germany's position in foreign trade with knowledge-intensive services due to the shortage of good data, and various special factors. The balance of payments has improved between 1999 and 2006 for all knowledge-intensive services. However, direct exports only cover a small part of the trade in these services. They can frequently only be sold through local subsidiaries, because the performances require direct contacts with the customers. Almost all knowledge-intensive services generate a large proportion of their turnover through their foreign subsidiaries, and this business has been growing more rapidly in recent years.

RESEARCH AND DEVELOPMENT

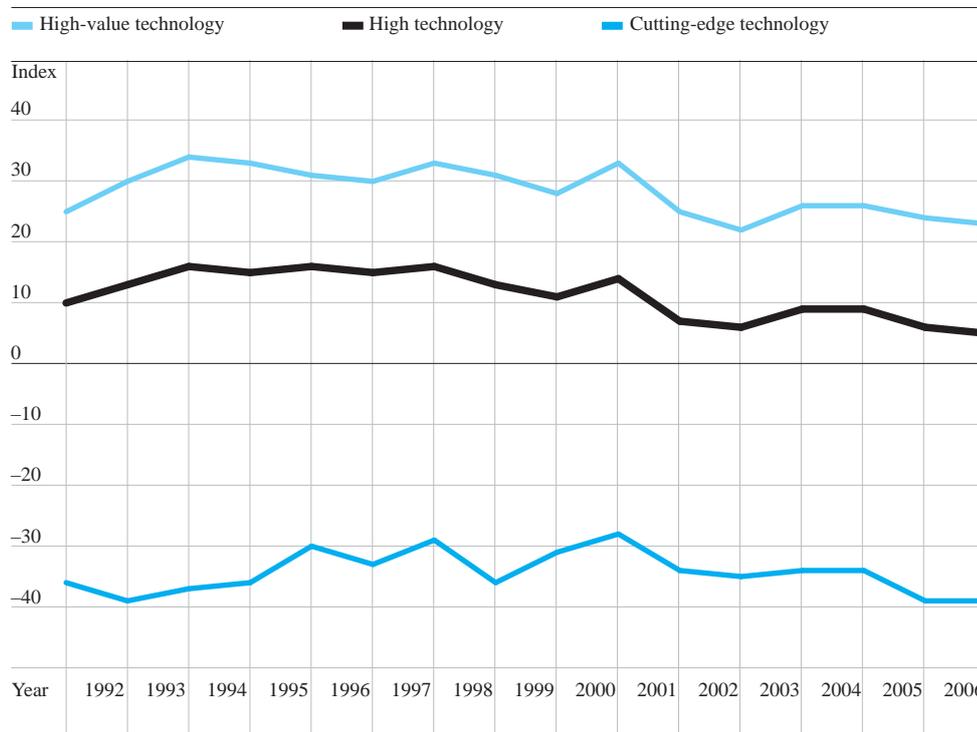
Research and development (R&D) in business, universities and scientific institutions plays a central role in the chain of education and qualification, science, research and technology, inventions, investments and innovations, productivity, international competitiveness, growth and employment.⁷⁶ All empirical studies show a generally positive influence of R&D on macroeconomic parameters. In addition, however, there are a series of other influential factors, complex interactions and a variety of pre-conditions. In short, R&D in highly developed economies is necessary but not sufficient for innovation processes. Given the importance of research-intensive industries and knowledge-intensive services for production, the generation of employment, and foreign trade, R&D is a key element for the development of the technological potential of Germany.

In-house research and development increasingly important for companies

More innovators in Germany are carrying out their own R&D. In 2006, two-thirds of industrial innovators carried out their own R&D, whereas in 1998 it had been a half. Germany has a good position for R&D in an international comparison. In the 1980s it was one of the leading industrialised countries – in a phase in which R&D capacities was expanding very rapidly worldwide. This had been the result of an enormous intensification of R&D in Germany in almost all branches of industry, together with a transformation of the industrial structure and a shift

Revealed Comparative Advantage (RCA index) of Germany in foreign trade with R&D-intensive products

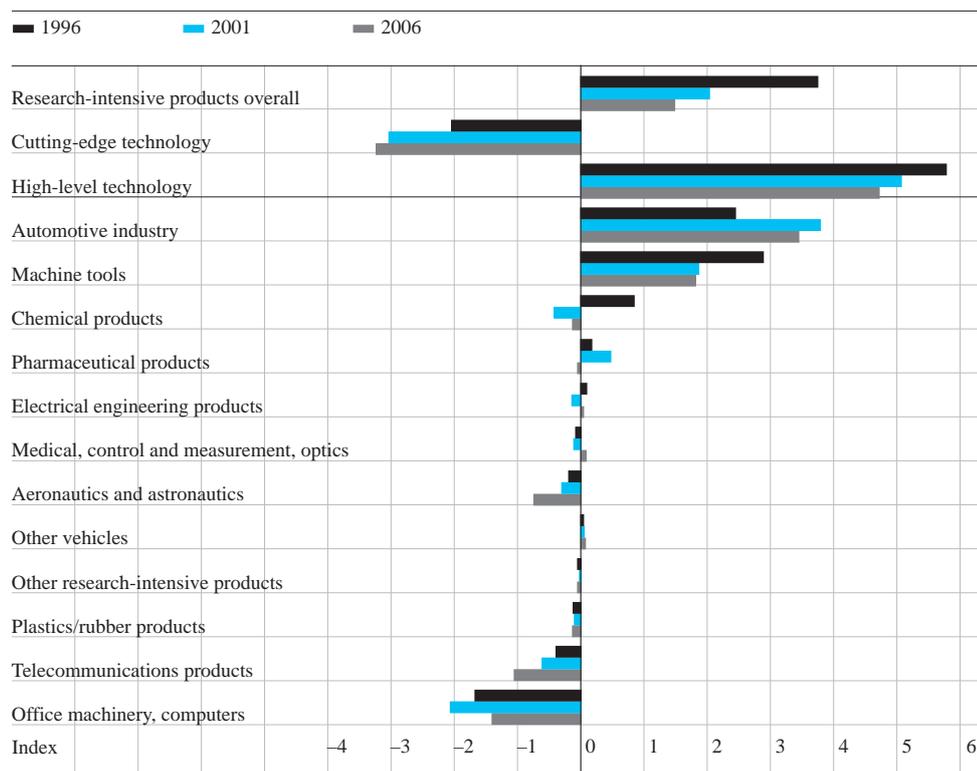
FIG 09



RCA index: A positive value means that the export-import relation for Germany in this technology group is higher than this relation for all processed industrial products.
Source: UN. Calculations by RWI.

Contributions of R&D-intensive goods to the German balance of trade

FIG 10



BAS index:⁷⁷ A positive value shows that the group of products makes a contribution to the German balance of trade which is above the average for all manufacturing industries.
Source: UNO. Calculations by RWI.

towards research-intensive manufacturing sectors. This dynamic came to a standstill in the early 1990s, and the R&D intensity in Germany had fallen markedly by the mid-1990s.

In the second half of the 1990s there was a rise worldwide in R&D intensities, followed again by a stagnation of development. The changes in the current decade have affected in particular the USA, which experienced a considerable drop in R&D between 2000 and 2002. This meant that Germany had now almost reached the American R&D intensity (Figure 11). However, this has not been due to an increase in its own efforts, with the exception of the recent increase in the macroeconomic R&D intensity in 2006.

Of the countries compared, the steady relative growth of R&D expenditure by Japan since the mid-1990s is remarkable. In the 1990s, Finland and Sweden started a massive increase in R&D activities, although this was slowed down by the end of the New-Economy boom in 2001 (in particular in Sweden). Both countries are still in the lead with R&D intensities in 2005 of 3.8 per cent and 3.4 per cent, respectively. Among the smaller countries, Switzerland and Korea have high R&D intensities, with three per cent in 2005.

Three-percent goal still a long way off

The EU-15 countries in all still only spend 1.9 per cent of their domestic products on R&D. This has not improved since the start of the 1990s, and they continue to lag behind the USA and Japan. The European Union is far from the three percent goal it has set itself for 2010. Whereas Germany at the start of the 1990s still held a leading position for R&D intensity, it is currently only in the upper-middle ranks. Some years ago it regarded the USA and Japan as the measure for international technology competition, but now reference is often made to the much lower average value for the EU-15. It would seem that with a view to international competitiveness a reference to the OECD member countries would be more appropriate. Despite a relative improvement since the mid-1990s, the advantage of Germany with regard to R&D intensity has been considerably reduced over the long term. Many OECD member countries have continually increased their efforts in this sector in recent years. And the technology competition with newly industrialised countries has also become considerably more intense.⁷⁸ With a macroeconomic R&D intensity of

about 2.5 per cent, Germany will not be well-placed in the long term for technology competition.

Although production development in Germany has been undergoing a restructuring process towards more cutting-edge technology, it has not quite reached international rates of growth. The German cutting-edge technology now stands up well to an international comparison of specific R&D intensity – with the exceptions of the information and communications sector and pharmaceuticals.

In the worldwide transformation of R&D structures, there has been a marked decline in high-level technology, in which Germany has traditionally been strong. A positive exception is the automotive industry, in which there was a marked increase in R&D in the 1990s. This has been primarily responsible for the fact that over the past decade the level of R&D activity of the German economy has remained at a high level. Germany's share of R&D in the automotive industry among the most important industrialised countries has thus increased over the long term from 10 to 25 per cent.

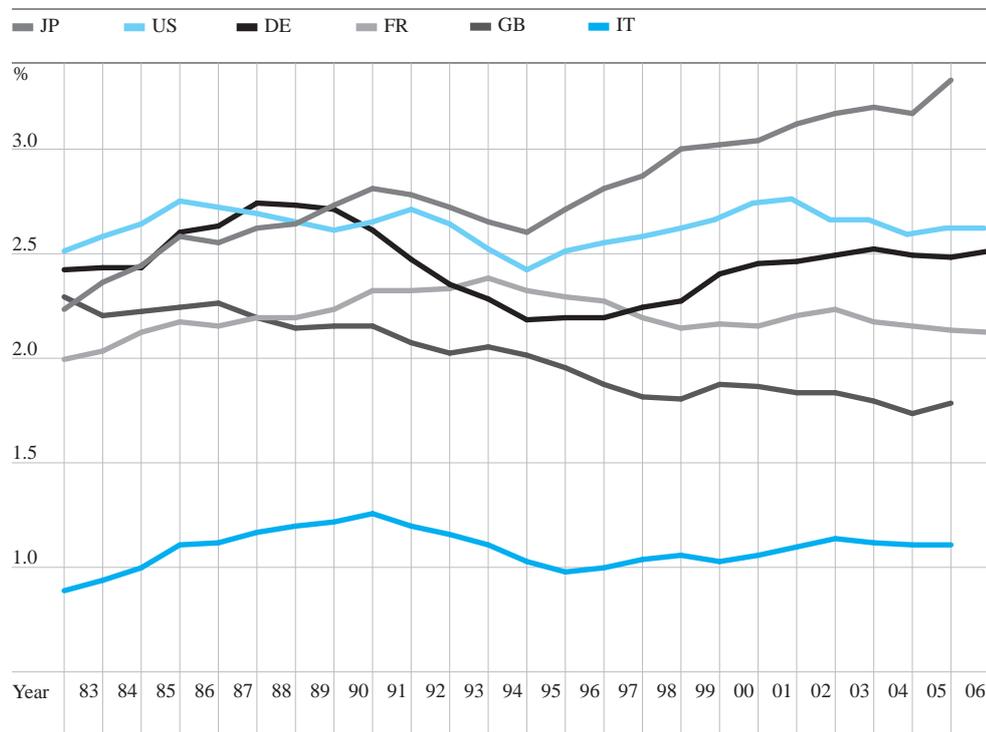
Rising R&D intensity in pharmaceuticals and the automotive industry

Rankings of industries according to R&D intensity are very similar for most countries. There have been some slight changes in Germany over the past decade. Structural changes have seen aeronautics/astronautics, electronics/telecommunications and computer/office machines overtaking by the pharmaceutical industry, and also by instrument construction and the automotive industry (Figure 12). In a series of industries increases in R&D expenditure have often not kept pace with the growth in turnover, which has led to declining R&D intensities.

Knowledge-intensive services are growing in importance both in terms of value added and also as a motor for innovation. They contribute above all as users to the diffusion of innovative technologies, and also define new demands on technologies, which in turn has an effect on the R&D of companies. High-value service providers are in contact in particular with those sectors of industry which carry out advanced R&D. For reasons of efficiency, there has been a growing division of labour between manufacturers and the specialised R&D, planning and engineering service providers. In

Proportion of GDP spent on R&D by selected OECD member countries

FIG 11



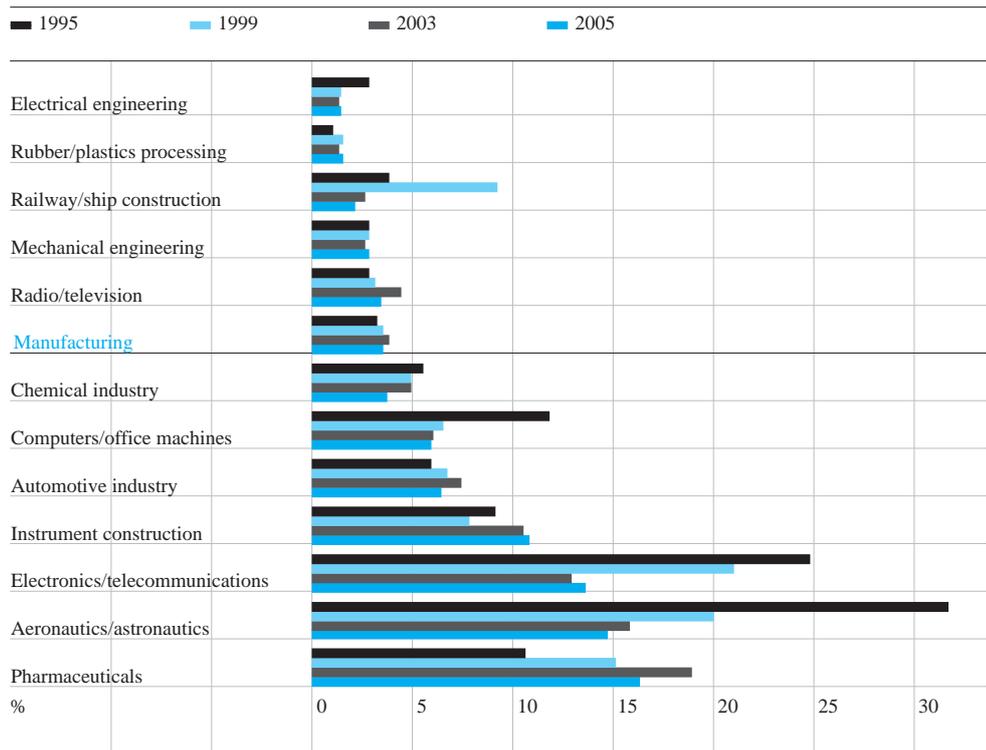
Data estimated in part.

R&D expenditure slightly overestimated in Japan until 1995. Until 1990: West Germany.

Source: OECD, Main Science and Technology Indicators (2007/2). Calculations and estimates of NIW.

R&D expenditure relative to turnover for selected sectors

FIG 12



Source: SV-Wissenschaftsstatistik, StaBuA, FS 4, 4.1.1 and 4.3. Calculations by NIW.

Germany, businesses are attaching more and more importance to research and development for high-level services.

R&D is often hard to identify in services companies, because the available statistical instruments are oriented towards innovation activities in the manufacturing industries. Innovations in the services sector are much less dependent on R&D than in manufacturing industry, but despite the statistical difficulties, the data clearly shows a structural change. Whereas at the start of the 1980s only one per cent of R&D personnel were working in the services sector, this had increased by the early 1990s to three per cent, and is currently at eleven per cent. Nevertheless, Germany is still far behind in an international comparison.

Current R&D expenditure declining in manufacturing industry, rising in services sector

In 2005 R&D personnel increased by 1.5 per cent, above all in the services sector and in SMEs. Manufacturing industries reported a reduction of internal R&D activities (down 1.2 per cent). In particular large manufacturing companies cut back on R&D personnel and reduced expenditure on R&D. SMEs providing business-related services, on the other hand, have recruited more R&D personnel. This is a reflection of an increase in R&D outsourcing.

The decline in internal R&D expenditure is concentrated in the automotive industry, ICT, electrical engineering, media technology, measurement and control technology, and the chemical industry. In contrast, there have been increases in the pharmaceutical industry and the mechanical engineering.

Short-term demand developments determine R&D activities

Ideally, R&D activities would be anti-cyclical, with developments during periods of economic stagnation preparing for phases of dynamic growth. But since the start of the 1990s it has been possible to observe an increasing pro-cyclical link between economic cycles and R&D activities. However, even the economic upswing since 2005 initially showed no signs (until 2006) of having been used for above-average investments in the development of new technical knowledge. R&D is increasingly oriented towards short-term changes in demand and the prospects of growth in the near future.

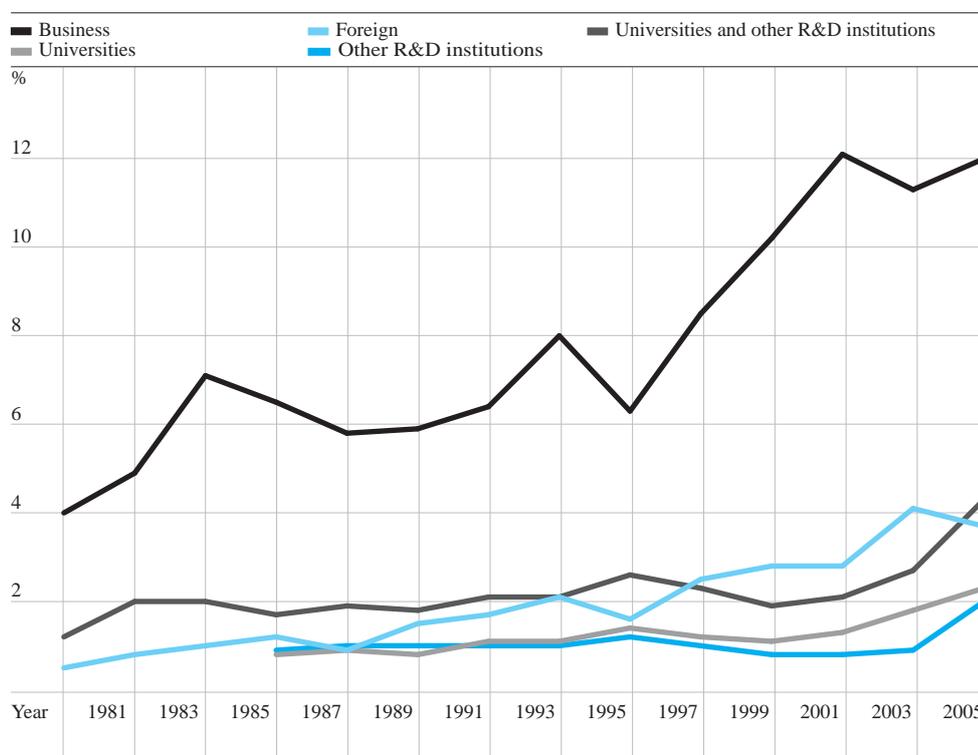
Reversal of decline in government support for R&D?

In recent years, increasing attention has been paid to research and development as a factor for the international competitiveness. Many states are now once again increasing their efforts in this sector, after withdrawing from R&D-financing over previous decades. Government contributions to R&D financing relative to GDP had fallen in the OECD member countries from 0.92 per cent (1985) to 0.83 per cent (1990) and 0.63 per cent (2000), and in Germany from 0.98 to 0.77 per cent over this period. Important reasons for this decline were the cut-backs in military R&D after the end of the Cold War, growing budgetary constraints, and the reduction of public funding for controversial large civil projects, in particular manned space travel and nuclear power.

In this decade, public R&D financing rates in the OECD increased to 0.66 per cent (2005). This is mainly due to increased state backing in the USA for basic research in the natural sciences and military research. This has provided extremely strong impulses. For example, research expenditure in the health sector in the USA was 34.5 billion US dollars (2005),

External R&D expenditure by sector of performance (as per cent of total R&D expenditure)

FIG 13



Source: SV-Wissenschaftsstatistik. Calculations by NIW.

compared with only 2.9 billion US dollars in Germany. There are not yet any signs in the German data of a trend towards more public R&D expenditure.

Increasing third-party R&D contributions

R&D processes in the economy have become an increasingly important competitive factor in recent years, however human resources and capital have also become more scarce. Business companies are therefore concentrating their internal R&D increasingly on their 'core competence' and outsource R&D assignments. Only 5.7 per cent of business R&D projects were being out-sourced at the end of the 1970s, but today this has increased to 20.3 per cent. This applies in particular for large companies. Overall, about 60 per cent of external assignments are placed with German companies, 18 per cent go abroad and some 22 per cent are placed with scientific institutions.

There has been a significant rise in orders placed with German companies since the start of the 1990s. This is a reflection of strategies to outsource activities of lower strategic importance to services companies or suppliers. There has also been an increase in R&D cooperation within corporate groups. Almost half of all R&D contracts are carried out with associated domestic or foreign companies.

Growing importance of universities as R&D cooperation partners

In particular since 2001, universities have become more important as R&D cooperation partners for business companies. The share of overall R&D expenditure going to non-university institutions had been declining since 1995, but has now risen again and has almost reached

the level of the universities. It has to be borne in mind that the non-university institutions frequently provide supporting services for innovations which are not directly classified as research and development, and that as a result their importance for the innovation processes are considerably underestimated if only R&D projects are considered. Public institutions are above all an important partner for the external orders from SMEs. In general, external R&D activities increase with the level of technology involved. In cutting-edge technology, a particularly large proportion of R&D work is carried out by external commissions.

R&D expenditure currently increasing

In 2006, overall R&D expenditure increased by 7.4 per cent over 2005. The figures for 2007 are expected to show a further increase of 4.2 per cent. This is the start of a necessary process of catching up with a number of other countries who have steadily increased the proportion of added value spent on R&D. The rates of increase for 2006 and 2007 are above the rate of inflation and the growth rate of the gross domestic product; companies have invested more in research and development in real terms.

The numbers of personnel employed in R&D and innovation has been increased in 40 per cent of companies, and the total is expected to increase by 3.5 per cent. However, more than 20 per cent of companies were not able to recruit as many R&D personnel as planned. This is obviously already a consequence of the shortage of qualified specialists.

D 3 SPECIAL TOPICS OF RESEARCH AND DEVELOPMENT

The following section addresses three special topics which are closely related to research and development. Additional information is included on production, foreign trade, patents and publications.⁷⁹

D 3-1 GERMANY IN GLOBALISATION

The past decade, in particular up to 2001, has been marked to a strong trend to globalisation. The German public have been increasingly worried about a growing trend for German companies to relocate production in other countries. But another key aspect is the relocation of R&D activities. In 2005, 76 per cent of R&D activities in Germany were being carried out by companies which did R&D in other countries.

Ten years earlier the figure had been 69 per cent. On the one hand, companies who are not involved in the internationalisation of R&D have been contributing less and less in recent years to R&D in the German economy; on the other hand, increasing numbers of companies involved in R&D are also becoming active in other countries – a reflection of the growing export orientation of the German economy.

The internationalisation of the innovation activities of companies has in particular been reinforced in the second half of the past decade in a wave of transnational mergers and acquisitions. But of course many foreign companies have also been carrying out R&D work in Germany for a long time. Foreign companies spent EUR 1.2 billion more for R&D in Germany than German companies did in other countries. German companies carry out about a quarter of their R&D in other countries; equally, about a quarter of R&D activities in Germany are carried out by foreign companies.

Germany is the second largest R&D location for foreign companies

After the USA (25.5 billion euros) and before Great Britain, Germany is the second most important R&D location for foreign companies with an expenditure of 12.6 billion euros.

Germany is also the second most important location after Great Britain for US-subsidaries, and these show the highest R&D intensity in comparison with other location countries. In the dynamic of R&D expenditure by American companies, however, Germany and Great Britain are both far behind countries such as Sweden, Ireland, China, Israel, and Canada. Overall, Europe has become less important for R&D investments by American companies than locations in Asian newly industrialising countries.

Germany shows overall benefits from R&D globalisation and has proved particularly attractive for foreign subsidiaries. In the mid-1990s, foreign companies accounted for some 15 per cent of R&D potential in Germany, and this share has since increased to 26 per cent, mainly due to mergers and acquisitions from 1997 to 2001. These have resulted in existing R&D capacities being acquired and then extended in parallel to the activities of German companies. In recent years, the globalisation of industrial research in Germany has slowed down. Between 2001 and 2005 the